





Montana Department of Transportation
PO Box 201001
Helena, MT 59620-1001

Memorandum

To: Jim Davies, P.E.
Project Design Engineer - Road Design Section

From: Scott Helm, P.G. 
Geotechnical Manager - Butte District

Patrick S. McCann, P.E. 
District Geotechnical Engineer - Butte District

Date: August 24, 2007

Subject: NH-F 8-4(16)78
Townsend – South and Townsend – South Passing Lanes
CN: 1420000 and 1420001
Geotechnical Engineering – Alignment (Activity 464) Report
Addendum #1: Revisions based on PIH meeting

The Geotechnical Section has completed its analysis for alignment and minor structure features for the subject projects. This report is being issued to address comments and design decisions resulting from the PIH meeting held July 11, 2007. A decision was made at the PIH meeting to split the original project into two different projects, Townsend – South and Townsend – South Passing Lanes, for funding reasons.

Location

Both projects are located on US 287 in Broadwater County, in Township 6 North, Range 2 East, Sections 5, 6, 8, 16, 17, 21, 27, 28, and 34 and Township 5 North, Range 2 East, Sections 3 and 10. The original project limits were station 24+60 (RP 78.1) to station 156+60 (RP 86.3).

Based on the PIH Report, the Townsend – South project limits are now from RP 78.1 to RP 82.5, with the split being located at approximately station 93+60 and the connection to the PTW extending to approximately station 99+60. The Townsend – South Passing Lanes project will begin at RP 82.5 and end at RP 86.3. A formal split memo has not been received as of this writing.

Intent

It is our understanding that the intent of these projects is to reconstruct this portion of US 287 to current road design standards. The work will include a horizontal alignment shift to the east of the current PTW throughout most of the project. Minor changes to the vertical alignment will be made to address drainage facilities, structures, and to improve

stopping sight distances as necessary. The design speed for this project is 110 km/h. Several passing lanes are also proposed for the projects.

Synopsis

This Report provides the results of subsurface exploration and Geotechnical engineering studies and Geotechnical recommendations for the design and construction of the alignment and minor structure features for both projects. A separate report will be provided for the bridge structure proposed for the Townsend - South project. This Report includes brief descriptions of the areal geology and our field investigation. Also included are recommendations for embankment foundations (standard and shot rock based); embankment foundation settlement estimates; culvert foundations; embankment and cut slope ratios; subgrade treatment; and moisture sensitive soils for both projects. Appropriate Special Provisions and Details are included.

Areal Geology (Both Projects)

The area is mapped as alluvium and Greyson Shale. Alluvium (Qa) is mainly stream laid sands and gravels. The sands and gravels are poorly graded and well rounded within the Missouri River floodplain and well graded and poorly rounded in areas outside the floodplain. Greyson Shale is composed mainly of green-gray siltite and fine quartzite. Based on the geologic mapping in this area, the alluvium ranges from 60 to 120 meters in depth throughout the project areas. As anticipated prior to drilling, formation was not encountered during our investigation. Surficial soils have been mapped throughout the project corridors as silts, sandy silts, and clays.

Field Investigation (Both Projects)

From January 6 to June 22, 2006, the MDT Field Investigation Unit advanced 73 borings throughout the original project. Drilling was conducted in 3 separate phases (phases I, II, and III). One boring was conducted for a minor cut section and the remaining borings were drilled to determine proposed embankment and/or culvert foundation characteristics.

The original project was arbitrarily broken into 3 sections, based on distance along the project corridor, field observations of soils and groundwater conditions, and preliminary laboratory test and analysis data. The three sections are as follows: Section 1(Northern Section): Beginning Of Project (BOP) to Station 70+00; Section 2 (Middle Section): stations 70+00 to 114+00; Section 3 (Southern Section): station 114+00 to End Of Project (EOP).

Section 1 Observations (Townsend – South Project):

Section 1 has 18 borings within the corridor, with depths ranging from 2.7 to 8.1 meters.

Soils Encountered:

The following soil types were encountered during the subsurface investigation:

- Silts with varying amounts of sand and gravel.
- Sands with varying amounts of silt and gravel.
- Gravels with varying amounts of sand and silt.
- Clayey Sands and Gravels (encountered at depth at the Deep Creek structure).
- Lean, Fat, and Silty Clays.
- Elastic Silts.

Soils Class Range:

The soils encountered fell within the following AASHTO Soils Classification ranges:

- A-1-a to A-7-6.

The majority of shallow (<6m) soils are composed of A-4, A-6, and A-7 soils.

Densities/Consistencies:

The soils encountered exhibited the following density/consistency ranges:

- Cohesionless material densities range from very loose to very dense but are primarily in the loose to medium dense categories.
- Cohesive material consistencies range from very soft to medium stiff but are primarily in the very soft to soft categories.

Groundwater Levels:

- Groundwater levels ranged from 0.8 to 5.2m, while drilling. Groundwater was encountered in all 18 borings. The northern portion of Section 1 exhibits surficial alkali deposits indicative of shallow groundwater levels that undergo frequent fluctuations. Some of this may be attributable to the seasonal use of the Montana Ditch to convey irrigation water. It is anticipated that groundwater levels will fluctuate seasonally.

General Soil Profile:

The general soil stratigraphy encountered is as follows:

- 0.9 to 6.2m of cohesive/fine grained material overlying denser sands and gravels.

Liquidity Indices:

Experience has shown that operation of construction equipment becomes inefficient when the Liquidity Index (LI) exceeds approximately 0.35 and may become unworkable when values exceeding 0.5 are indicated.

- LI's range from **0.0 to 1.78**.
- Of the values observed, 31 values over 0.3 were recorded, **indicating that potentially problematic soils are prevalent in this portion of the project.**

Section 2 Observations (for portions of both projects):

Section 2 has 37 borings within the corridor, with depths ranging from 0.9 to 9.6 meters.

Soils Encountered:

The following soil types were encountered during the subsurface investigation:

- Silts with varying amounts of sand and gravel.
- Sands with varying amounts of silt and gravel.
- Gravels with varying amounts of sand and silt.
- Clayey Gravels.
- Lean, Fat, and Silty Clays.
- Elastic Silts.

Soils Class Range:

The soils encountered fell within the following AASHTO Soils Classification ranges:

- A-1-a to A-7-6.

The majority of shallow (<6m) soils are A-4 and A-7.

Densities/Consistencies:

The soils encountered exhibited the following density/consistency ranges:

- Cohesionless material densities range from very loose to very dense but are primarily in the very loose **and** medium dense categories.
- Cohesive material consistencies range from very soft to very stiff but are primarily in the very soft to soft categories.

Groundwater Levels:

- Groundwater levels ranged from 0.0 to 5.8m, while drilling. Groundwater was encountered in 36 of the 37 borings. No groundwater was encountered in boring 1420-033 (Station 113+22). It is anticipated that groundwater levels will fluctuate seasonally.

General Soil Profile:

The general soil stratigraphy encountered is as follows:

- 0.6 to 4.3m of cohesive/fine grained material overlying denser sands and gravels.

Liquidity Indices:

- LI's range from **0.0** to **6.35**.
- Of the values observed, 23 values over 0.3 and 19 values over 0.5 were recorded, **indicating that potentially problematic soils are prevalent in this portion of the project.** The area from approximately station 87+00 to 98+00 will be especially problematic with respect to the surficial soils and due to standing water/ponds. This area also contains soils that are either organic or contain a significant amount of organic material within the soil mass structure (i.e. rotted wood, roots, cattails, reeds, etc.)

Section 3 Observations (Townsend – South Passing Lanes Project):

Section 3 has 18 borings within the corridor, with depths ranging from 1.5 to 9.6 meters.

Soils Encountered:

The following soil types were encountered during the subsurface investigation:

- Silts with varying amounts of sand and gravel.
- Sands with varying amounts of silt and gravel.
- Gravels with varying amounts of sand and silt.
- Silty, Clayey Sands.
- Lean and Fat Clays with varying amounts of sand.
- Elastic Silt.

Clays and silts/elastic silts constitute the vast majority of soils encountered in Section 3.

Soils Class Range:

The soils encountered fell within the following AASHTO Soils Classification ranges:

- A-1-a to A-7-6

The majority of shallow (<6m) soils are A-7.

Densities/Consistencies:

The soils encountered exhibited the following density/consistency ranges:

- Cohesionless material densities range from very loose to very dense but are primarily in the loose category.
- Cohesive material consistencies range from very soft to very stiff but are primarily in the medium stiff category.

Groundwater Levels:

- Groundwater levels ranged from 3.0 to 6.1m, while drilling. Groundwater was encountered in 2 of the 18 borings, 1420-002 (Sta. 115+25) and 1420-032 (Sta. 116+18). Groundwater was not encountered in any of the remaining borings at the time of drilling. However, it is anticipated that groundwater levels will fluctuate seasonally.

General Soil Profile:

The general soil stratigraphy encountered is as follows:

- 1.8 to 6.1m of cohesive/fine grained material overlying denser sands and gravels.

Liquidity Indices:

- LI's range from **0.0** to **1.45**.
- Of the values observed, 10 values over 0.3 recorded, **indicating that potentially problematic soils are present in this portion of the project.** However, the higher LI values were only encountered in very isolated areas within this section of the project.

The following table lists which borings belong to each project. The borings within the connection for the **Townsend – South** project are included in that project list. The borings are listed from BOP to end of connection for each project.

PROJECT	BORINGS
Townsend – South	1420-046, 052, 053, 051, 064, 050, 047, 048, 049, 045, 044, 043, 063, 062, 042, 065, 041, 040, 054, 055, 056, 057, 058, 016, 059, 060, 015, 014, 061, 066, 067, 013, 012, 068, 070, 069, 011, 077, 078, 084, 010, 009, 008, 007, 006, 038, 039, 005, 004, 037
Townsend – South Passing Lanes	1420-036, 003, 034, 035, 033, 002, 032, 031, 029, 028, 027, 026, 025, 024, 023, 022, 021, 020, 001, 019, 030, 018, 017

Boring logs for both projects have been distributed with the original report, dated June 22, 2007.

Design Recommendations

Embankment Foundations

Proposed embankment foundation areas were evaluated for support characteristics and constructability throughout the original project. The District Soil Survey, Geotechnical subsurface investigation results, and visual observation of the foundation areas were used to develop our recommendations. The following recommendations apply only to the **Townsend – South** project and are not required for the **Townsend – South Passing Lanes** project.

Two types of embankment foundation treatment are proposed for this project, Standard (Embankment Foundation Treatment hereinafter) and Rock Fill Embankment Foundation Treatment (Modified Embankment Foundation Treatment hereinafter). Embankment Foundation Treatment consists of High Survivability Stabilization Geotextile and Special Borrow placed prior to embankment construction. Modified Embankment Foundation Treatment consists of 1.2 meters of Rock Fill, 150mm of Special Borrow (as cushion material to prevent geotextile installation damage), High Survivability Separation Geotextile, and Special Borrow placed up to the subgrade elevation.

Embankment Foundation Treatment is recommended, on the **Townsend – South** project, for the following areas due to the prevalence of soils with poor support characteristics, shallow groundwater levels, high liquidity indices, and other factors indicative of unsuitable near surface embankment foundation support:

- 37+30 to 45+00, Left
- 71+00 to 78+50, Left
- 81+00 to 82+00, Left
- 86+60 to 88+10, Left

For all Embankment Foundation Treatment areas, begin the treatment at the bottom of the PTW slope and extend perpendicular to within two meters of the toe of the proposed

embankment. Extend geotextile up the existing slope one meter as measured on the slope face. Bench existing slopes in accordance with Section 203.03.2 C of the Standard Specifications.

We recommend Modified Embankment Foundation Treatment, for the **Townsend – South** project, in the following areas due to the prevalence soils with poor support characteristics, high organic contents, surface or standing water/ponds, high liquidity indices, and other factors indicative of unsuitable embankment foundation support.

- 88+10 to 99+00, Left

For all Modified Embankment Foundation Treatment areas, begin by placing 1.2 meters of Rock Fill at the bottom of the PTW slope and extend perpendicular to the toe of the proposed embankment. Place 150mm of Special Borrow, as cushion material, over the Rock Fill. Place geotextile, starting one meter up the existing slope (as measured on the slope face) and extend perpendicular to with 0.5 meters of the proposed embankment slope. Finally, place Special Borrow up to the subgrade elevation. Special Provisions for Embankment Foundation Treatment, Modified Embankment Foundation Treatment, Special Borrow, and Rock Fill are attached.

Embankment Foundation Settlement Estimates

Proposed embankment foundation areas were evaluated for total settlement. Based on our analyses of representative embankments, foundation settlement estimates (rounded to the nearest 12 mm/ ½ inch) for each area analyzed are shown in the table below.

Approx. Station	Predominant Foundation Soil Type	Est. Settlement (mm/inches)	Est. Time for 90% Consolidation (days)
Townsend – South Project			
37+20	Elastic Silt and Lean Clay	150mm / 6" (or less)	119
44+53	Plastic Silt, Lean and Fat Clay	100mm / 4" (or less)	1,323 (3.6 years)
52+20	Lean and Fat Clay, Silt (all w/sand)	30mm / 1.5" (or less)	1,000 (2.7 years)
56+30	Lean Clay with sand	80mm / 3" (or less)	464
65+60	Fat Clay with sand, Silt	80mm / 3" (or less)	254
74+25	Plastic Silt with organics	100mm / 4" (or less)	40
77+20	Poorly Graded Sand and Gravel w/silt	12mm / 0.5" (or less)	*instantaneous
84+85	Lean Clay with sand	150mm / 6" (or less)	265
81+40	Sandy Silt, plastic	90mm / 3.5" (or less)	*instantaneous
86+60	Lean Clay	30mm / 1.5" (or less)	*instantaneous
89+60	Lean Clay/Elastic Silt	120mm / 5" (or less)	30
90+70	Sandy Elastic Silt	100mm / 4" (or less)	40

97+80	Silt/Sandy Silt with organics	180mm / 7" (or less)	25
Townsend – South Passing Lanes Project			
105+50	Sandy Lean Clay	12mm / 0.5" (or less)	300
108+00	Lean Clay	12mm / 0.5" (or less)	173
115+80	Lean Clay, Plastic Sandy Silt	90mm / 3.5" (or less)	823 (2.3 years)
123+51	Fat and Lean Clay w/sand	12mm / 0.5" (or less)	20
149+60	Fat Clay with Sand	12mm / 0.5" (or less)	1,060 (2.9 years)

*Instantaneous settlement is considered to occur over the course of construction (less than 20 days).

As seen in the table above, the estimated time for 90% consolidation of the embankment materials ranges from instantaneous (occurring over the course of construction) to as much as 3+ years, with most of the settlement occurring within a year or less. **It should be noted that all of the estimated settlement could be realized as differential settlement between the existing PTW and proposed embankments.** This differential settlement may cause distress in the paving section between the portion of the existing embankment and the newly constructed embankment. This distress could cause excessive longitudinal and transverse cracking leading to premature pavement failure. The estimated settlement will also affect proposed culverts on the project

Because of the time required for the majority of consolidation to occur and the potential for large differential settlement, we strongly recommend that the proposed embankments **(for the Townsend – South project)** be constructed up to the subgrade elevation and then be allowed to remain for a minimum of six months to allow the maximum amount of settlement to occur prior to construction to the final subgrade elevation. In addition, we strongly recommend a settlement monitoring program to evaluate (immediately after initial construction and during embankment settlement time) to determine when the rate of settlement has slowed to the point that any remaining settlement will not be detrimental to the stability of the paving section.

This monitoring program is normally accomplished by the use of settlement plates or other Geotechnical instrumentation. However, in the interest of reducing overall project costs, an alternative consisting of simple surveys of embankment top elevations could be done after initial embankment construction, to collect the data necessary to evaluate settlement rates.

Proposed initial survey requirements would be to monitor each of the points twice weekly for the first month, weekly the following two months, and monthly thereafter until either six months has passed or it has been determined that the majority of settlement has occurred.

Embankment Slopes

Proposed embankment slope ratios for both projects are a maximum of 4H:1V. In our opinion, the proposed embankment slope ratios are adequate for each project. If embankment design slope ratios require adjustment either in the design or construction phases of the project, the Geotechnical Section should be contacted to review the changes.

Culvert Foundation Treatment Areas

At the PIH meeting, the Geotechnical Section agreed to remove Culvert Foundation Treatment from pipes that were less than 900mm in diameter as a cost savings measure to both projects. Our revised recommendations for Culvert Foundation Treatment on both projects, consisting of 0.6m of subexcavation, geotextile, and foundation material, are as follows:

Townsend – South:

- Station 37+21.5
- Station 65+60
- Station 77+17.6
- Station 84+48

Townsend – South Passing Lanes:

- Station 110+83.5
- Station 147+20
- Station 149+60

A Special Provision for Culvert Foundation Treatment is attached.

Cut Slopes

The maximum proposed cut slope ratios for each project are 4H:1V or flatter. In our opinion, the cut slope ratios are adequate for the project. If slope ratios require adjustment either in the design or construction phases of the project, the Geotechnical Section should be contacted to review the changes. All project grading materials from proposed cut excavation areas are expected to be suitable for use elsewhere on either project with proper moisture and compaction control.

Subgrade Treatment

Throughout both projects, the proposed surfacing section consists of 120mm of Plant Mix Surfacing, 280mm of Crushed Aggregate Course, and 600mm of Special Borrow. The surfacing section is based on a design R-value of 20.

Field observations of the existing paving section do not indicate any substantial pavement distress due to poor subgrade conditions in the PTW. However, drilling results indicate some isolated areas that could be treated through the use of subexcavation of the PTW.

Additionally, the original alignment (constructed in 1939) was built predominantly from side borrow materials (silts and clays). This may indicate the need for some quantity of subexcavation to be included within the projects for bidding purposes in the event spot subgrade problem areas are encountered.

However, the recently completed VA study done for the original project included a recommendation (Creative Idea No: 2) to pulverize the existing plant mix surfacing (PMS) and blend it with the underlying base course, in lieu of excavating the PTW and replacing the excavated material with Special Borrow. This would be done in areas where the top of the existing PMS is below the top of the proposed Special Borrow. The design team agreed to incorporate this idea into the original project by Special Provision. It is assumed that this idea will be incorporated into the two new projects resulting from the split.

Additionally the original plans and cross sections indicate that either the VA study recommendation or the 600mm of Special Borrow will be utilized to construct the typical section throughout the entire original project length.

No specific subgrade treatment recommendations for either project will be made with this report based on:

- Subexcavation areas on the projects would be limited and potential material quantities are minor
- The incorporation of the VA study recommendation.
- The proposed use of typical sections with 600mm of Special Borrow
- Special Borrow and geotextile are included in the contract through other bid items

Bridge End Backfill (Townsend – South)

The Deep Creek structure is located within the limits of the **Townsend – South** project. The Townsend – South Passing Lanes project does not include any bridge structures. Bridge End Backfill, consisting of Crushed Aggregate Course, will be utilized at the Deep Creek structure. A Bridge End Backfill Special Provision is attached.

Moisture Sensitive Soils

Based on the information from the Geotechnical subsurface investigation and the District Soil Survey, moisture sensitive soils are prevalent throughout both projects. Small increases in moisture content are detrimental to the strength of these soils, possibly resulting in construction difficulties. A Moisture Sensitive Soils Special Provision is attached.

Miscellaneous

On the plan and profile sheets for both projects, the District Soil Survey holes should show the hole number in the plan view. The Geotechnical Section borings should be labeled with the proper boring identifier (i.e. CL 1420-15) in the plan view.

Professional judgments and recommendations are presented in this report. They are based partly on evaluation of the technical information gathered, partly on historical reports and partly on the Geotechnical Section's general experience with subsurface conditions in the area. The Geotechnical Section does not guarantee the performance of the project in any respect other than that the engineering work and the judgment rendered meet the standards and care of the profession. It should be noted that the borings may not represent potentially unfavorable subsurface conditions between borings. If, during construction, soil conditions are encountered that vary from those discussed in this report or historical reports, or if design loads and/or configurations change, the Geotechnical Section should be notified immediately in order that it may evaluate effects, if any, on foundation performance. The recommendations presented in this report are applicable only to this specific site. These data are not to be used for other purposes.

Questions regarding this matter may be directed to Patrick McCann, MDT Geotechnical Section @ (406) 444-6277 (pmccann@mt.gov), or Scott Helm @ (406) 444-6279 (shelm@mt.gov).

copies: Jeff Ebert, P.E. - District Engineer, Butte
 Bryan Miller, P.E. - Bridge Bureau, Helena
 Mark Goodman, P.E. - Hydraulics, Helena
 Deborah Wambach - Environmental Services, Helena
 Mac McArthur, P.E. - Construction Services Bureau, Helena
 Jake Goettle, P.E. - Construction Services Bureau, Helena
 Materials File
 Geotechnical File

Attachments: Bridge End Backfill Special Provision*
 Culvert Foundation Treatment Special Provision**
 Embankment Foundation Treatment Special Provision*
 Modified Embankment Foundation Treatment Special Provision*
 Moisture Sensitive Soils Special Provision**
 Rock Fill Special Provision*
 Special Borrow Special Provision**
 Boring Logs (See Geotechnical Report dated June 22, 2007)
 Boring Locations Strip Maps (See previous Geotechnical Report)
 Laboratory Test Summary (See previous Geotechnical Report)

Jim Davies, P.E.
UPN 1420000 and 1420001
464 Report Addendum #1

Page 12 of 12
August 24, 2007

- * Applies to Townsend – South project only
- ** Applies to both projects

SMH::psm S:\00_ACTIVE\1420\1420_MEMOS\1420_016.464reportrevised.DOC